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IMPROVED PROTECTIVE COATING FOR SONAR DOMES.(U)

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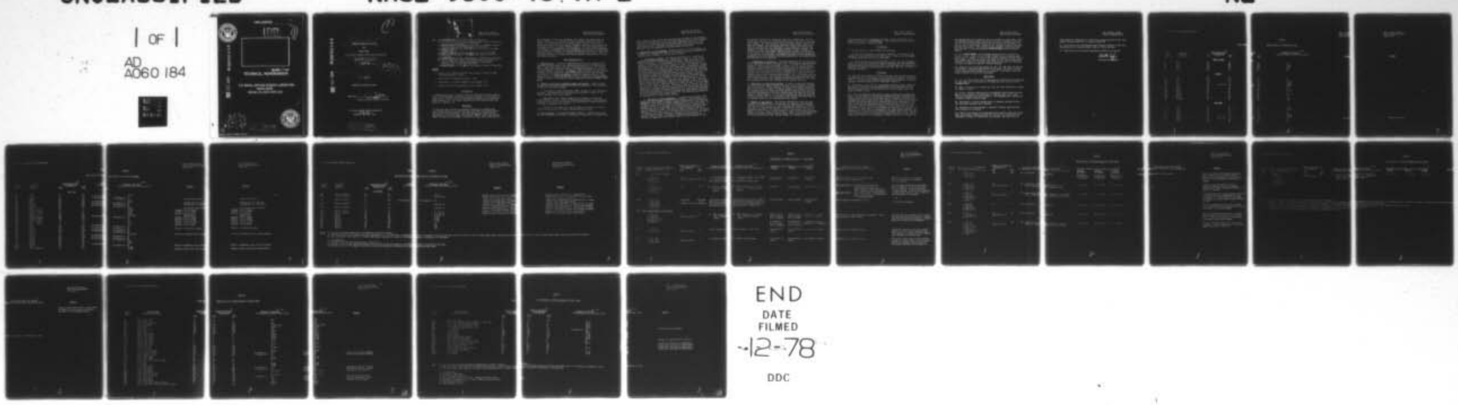

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TECHNICAL MEMORANDUM

U.S. NAVAL APPLIED SCIENCE LABORATORY
NAVAL BASE
BROOKLYN, NEW YORK 11251

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IMPROVED PROTECTIVE COATINGS FOR SONAR DOMES

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Lab. Project 9300-43
Technical Memorandum #2

Ref: (a) NAVUWTRSOUNDLAB Project Order 40016 of 4 Mar 1964
(b) Lab. Project 9300-43, Technical Memorandum #1, "Improved Protective Coatings for Sonar Domes" of 15 Jul 1964
(c) NAVAPLSCIENLAB Program Summary, Tasks 1201/2 and 8481/2, Improved Protective Coatings for Sonar Domes, of 1 Nov 1964
(d) NAVSHIPYD MARE ltr 9190, (303P-32912) of 18 Nov 1964 to CO USS COCHRANE (DDG 21)
(e) NAVSHIPYD MARE Paint Laboratory Report No. 64-5 of Jul 1964
(f) NAVSHIPYD NYK MAT LAB ltr 9370:EW:nr, Lab. Project 4759-14 of 13 Jun 1963
(g) NAVUWTRSOUNDLAB Technical Memorandum No. 930-219-62 of 12 Oct 1962
(h) J.Z. Lichtman, D.H. Kallas, C.K. Chatten and E.P. Cochran, Jr., Cavitation Erosion of Structural Materials and Coatings. Corrosion, Vol. 17, Oct 1961, 497t-505t
(i) NAVAPLSCIENLAB ltr 9370:AWC:nr, Lab. Project 9300-43 of 4 Sep 1964

TABLES

1 - Coded list of component coatings used to make up coating systems (and manufacturers) (6 pp)

2 - Test results of component coatings (3 pp)

3 - Test results of coating systems for sonar domes (3 pp)

4 - Test results of coating systems for sonar domes (2 pp)

Introduction

1. Work which has been initiated at the U.S. Naval Applied Science Laboratory on the development of improved protective coatings for sonar domes, as authorized by reference (a), is continuing as outlined in the program summary, reference (c). This report describes the work completed since submission of reference (b).

Background

2. The sonar dome surfaces are currently coated with a standard Navy vinyl system consisting of vinyl F119 plus vinyl F121 antifouling coating applied over F117 pretreatment. The high level acoustic pulse fields generated by current high power sonar systems (SQS-26) cause rapid deterioration of these coating systems in service to a state which interferes with

the performance of the sonar equipment. As a result, the window areas of numerous domes are left uncoated in order to prevent interference with the sonar. To prevent accumulation of marine growth, divers are required to periodically clean the metal surfaces. However, since the metal surfaces are uncoated, corrosion is severe. The development of a coating system that has good adhesion, is unaffected by sonic pulsations, is acoustically transparent, has good erosion resistance and has satisfactory anticorrosive and antifouling characteristics, is required to overcome the present difficulties. Also, the component coatings of a system should have comparable flexibilities to form a well-adhering system.

Work Program Details

3. Problem review - In order to understand more fully the difficulties encountered with the present vinyl coating system applied to the SQS-26 sonar domes, a review was made of the type of failures experienced. The difficulties as described in reference (g) are considered representative. The failures and probable causes are: (1) erosion, caused by motion of paint relative to water, possibly affected by water flow patterns or high level acoustic pulse fields, (2) flaking and peeling, caused by inadequate control of the painting process or poor adhesion of the coating system, and (3) spot erosion, caused by acoustic transmission producing severe and localized flexing of the paint.

4. Properties and types of materials under investigation - Work is being focused on the following properties and types of materials in the development of improved sonar dome coatings:

a. Low pigment volume concentration (PVC), especially of the antifouling top coat. (The standard vinyl antifouling top coat F121 is believed too heavily pigmented with cuprous oxide.)

b. Elastomeric type coating systems such as neoprene, polyurethane, polyisobutylene, hypalon, thiokol, and flexibilized epoxies. These materials are known to be more erosion resistant than hard resinous binder coatings, as indicated in references (f) and (h).

c. Toxics, of the newer type, such as organo-tin compounds or combinations with cuprous oxide for use in the antifouling top coat.

5. Test procedure - To evaluate candidate coatings, a screening test procedure was established as outlined in reference (b) that uses the standard Navy

vinyl system as a "control." Only coatings showing promise in the screening tests will be applied to 5 ft. x 5 ft. sonar dome sections and then forwarded to the U.S. Navy Underwater Sound Laboratory Dodge Pond facility for simulated service tests. Coatings that show promise in the simulated service tests will then be scheduled for shipboard trial applications.

6. Description of test equipment - A description of the test equipment, as referred to in reference (b), and the test procedures used for screening the coatings given in Tables 2, 3 and 4, are as follows:

a. Resistance to impact. The relative flexibility of a coating, expressed in percentage elongation, is determined by means of a G.E. Impact Flexibility Tester. In this apparatus the coating under evaluation is subjected to the impact of an approximately 3-3/4 lb. cylindrical impacter dropped through a guide tube from a height of 4 feet. The impacter strikes the reverse side of a coated steel test panel which is supported on a rubber pad at the base of the tester so that the circular imprint of the impacter is barely definable in the metal panel. Each end of the impacter is studded with a group of protruding spherical knobs, 5 on one end, 3 on the other end. The spherical segments of the knobs are calibrated in terms of percent flexibility, based on the elongation they can produce in the metal panel. The impacter gives readings of 1/2, 1, 2, 5 and 10% elongation on one end, and 20, 40 and 60% elongation on the other end. Thus, a total of ten different ratings may be assigned, ranging from below 1/2% to above 60% elongation of a test coating. When the impacter strikes the panel, the knobs form their imprints under the coatings. A reading is made by observing the last indentation in ascending order to show no cracking of the coating under test. The flexibility-impact tests were performed on a 1.5 mil dry film thickness of the coatings applied to 5" x 5" x 31 gauge mild steel panels primed with a 0.5 mil dry film of F117 primer (Code I-1). All coatings were allowed to air dry from 10 to 14 days before testing.

b. Resistance to sonic pulsations. To simulate the cavitation type erosion and film breakdown resulting from exposure to sonic pulsation, an "AUTOSONIC" Model PA3001 ultrasonic cleaner, manufactured by the Powertron Ultrasonics Corp., Roosevelt Field, Garden City, L.I., N.Y., was used. This equipment consists of a generator and a stainless steel ultrasonic tank. The generator has an output power of 300 watts and 1200 watts peak, with a nominal frequency of 28 KC. The stainless steel ultrasonic tank has a capacity of 3-1/2 gallons and is 9" long x 10" wide x 10" high. The generator activates the sealed ultrasonic transducer in the bottom of the tank to produce ultrasonic waves. Coatings for evaluation were applied to 5" x 5" x 31 gauge mild steel panels, similar to those prepared for the

resistance-to-impact test, which were mounted in a wooden rack, with the coated panel face down and 2-3/4" from the bottom of the tank of the ultrasonic cleaner. The tank was filled with fresh water totally immersing the rack and the panel. The ultrasonic cleaner produces intense sound waves above the audible limit (28 Kilocycles). This creates the formation and rupture of millions of voids (bubbles) thousands of times a second. The implosion of these voids creates enormous forces (30,000 to 50,000 psi) in the area of the coated panel. The resulting "scrubbing action" results in the erosion of the coating. The erosion resistance of the coatings was measured by the time required for initial perforation of the coating film to the substrate or to an undercoat.

c. Resistance to cavitation. A detailed description of the cavitation erosion apparatus is given in reference (h). This apparatus consists essentially of a water-filled test chamber in which a 12" dia. x 1/8" coated specimen is rotated under controlled conditions of fluid pressure and disk rotational speed. The disk is rotated in the chamber at 3200 R.P.M. to produce linear peripheral velocities of 100, 125 and 150 fps at radial hole locations of 3.57, 4.46 and 5.36 inches, respectively. Condition of the coatings after 1 hour of exposure was observed. It is to be noted that the erosion resistance with this equipment is beyond the range obtainable with the ultrasonic-cleaner. Only coating systems showing promise in the ultrasonic-cleaner test are being subjected to the rotating disc test.

7. Field tests of antifouling coatings. In order to guide the Laboratory with respect to the type of toxics to be used in the development or selection of suitable antifouling coatings for sonar domes, coating systems 1A, 8G and 8H as listed in Table 3 are being exposed at the Miami Test Station. The standard Navy vinyl system 1A (vinyl-cuprous oxide) is being used as a "control" for comparison with the 8G (epoxy-organo-tin TBTO) and 8H (vinyl-organo-tin TBTO) coatings. The 8G and 8H coatings were selected after the initial screening tests in the ultrasonic tank, wherein they were found to be somewhat better than the standard Navy vinyl system.

8. Summary of test results. The coatings evaluated and currently under evaluation, as referred to in this report, are composed of the component coatings identified in Table 1. This table has been arranged for deletion from copies of this report which may be intended for distribution to non-government activities. The results of tests of 140 coatings are shown in Tables 2, 3 and 4. Table 2 shows results of tests on the component coatings, namely, wash primers, primers and top coats. Table 3 gives the results of the more promising resin-type coating systems, the standard Navy vinyl

coating system used as a "control," and other coatings evaluated at the Dodge Pond facility of NAVUWTRSOUNDLAB. Table 4 provides the test results of the less promising coating systems.

Conclusions

9. The test results to date indicate the following:

a. The test procedures, as outlined in reference (b), using the test equipment as described herein, have been found to serve as suitable means for screening coatings for use on sonar domes.

b. Of all the coating systems evaluated to date, only the elastomeric types, utilizing such resins as urethanes, neoprenes, and polyisobutylene have shown much better performance than the standard Navy vinyl system. The promising elastomeric coating systems 9A, 22B, 22C, 22E, 22F, 25B and 25C are shown in Table 3.

Discussion

10. The G.E. Impact Flexibility Tester provided useful comparative data on the flexibility or the elongation of the component coatings as indicated in Table 2. The tester also provided significant data on adhesion of various component coatings to each other as indicated in Table 3.

11. The results of the tests on the component coatings, shown in Table 2, were useful in selecting the components with the most desirable and compatible characteristics for combination into coating systems, which are given in Tables 3 and 4.

12. It is considered that the results of test, as shown for coating 1D in Table 2 and 1A in Table 3, which were prepared under ideal laboratory condition, indicate that the primary reason for the premature failure of the standard Navy vinyl system was the poor adhesion of the F121 antifouling top coat and not improper application technique and surface preparation. This lack of adhesion was demonstrated by the relatively short period of time required to develop substantial flaking of the F121 antifouling top coat in the ultrasonic test, and the low elongation and cracking of the coating system in the impact test, as compared with the other coating systems. This deficiency is in accord with the premise of paragraph 3b(1) above, that the vinyl antifouling F121 is too heavily pigmented with cuprous oxide. Accordingly, on the basis of the foregoing, no further work will be conducted on

the standard Navy vinyl system for use as a coating for sonar domes. Also, the experimental Mare Island formulation described in Appendix A of reference (e) and currently under service test as indicated in reference (d), will be used as the "control" coating in this program instead of the standard Navy vinyl system. This coating system, designated as coating 24A-2, has shown merit in the laboratory and NAVUWTRSOUNDLAB tests as shown in Table 3.

13. The NAVAPLSCIENLAB coating system designated as 9A in Table 3 is similar in basic composition as the Mare Island coating system and shows similar merit. However, in view of the numerous component coatings used in both systems, the long application time taken, and the extreme precautions required in application to prevent film imperfections, work is continuing to reduce the number of component coatings required.

14. Although only the coating systems 9A, 22B, 22C, 22E, 22F, 25B and 25C show promise as candidate materials for sonar domes, the results of tests of the other coatings, referred to in reference (i) and Table 1, are provided in Tables 2, 3 and 4 for information.

Future Work

15. A 5' x 5' dome section will be prepared with the 22F coating system and will be submitted for evaluation to the Dodge Pond Test Facility of the NAVUWTRSOUNDLAB.

16. Work is continuing on coatings 9A, 22B, 22C, 22E, 25B and 25C to reduce the number of coats.

17. A sonic pulsation apparatus will be assembled shortly having a single SQS-26 sonar transducer for evaluation of coatings under actual sonar operating frequencies and pulse duration. This apparatus will replace the ultrasonic cleaner currently used.

18. Development of coating systems based on component coatings found to have desirable properties will continue.

19. Screening of coating systems or component coatings, made available from industry, will continue.

20. Based on the results of the exposure tests currently under way at the Miami Test Station, promising toxics will be used for incorporation into elastomeric coatings for antifouling top coatings. New toxics will be

investigated for development of antifouling coatings compatible with elastomeric coating systems such as coating system 22F.

21. Consultation will be maintained with Professor Kronstein of New York University, who is currently under a Bureau of Ships contract.

22. Participation with the Sonar Dome Working Group will continue.

Albert M. [illegible]
Principal Investigator

U.S. Naval Applied Science Laboratory

Test Resul

Coating No.	Component Code No. (1)	Flexibility-Impact (2) % Elongation 70°F		36°F
		Wash Primers		
1F	I(2)	60+		60+
4C	IV(1)	60+		60+
8B	IX(1)	60+		60+
5C	V(1)	60+		60+
6B	VI(1)	60+		10
		Primers		
1C	I(2)	60+		60+
2C	I(3)	40		40
9C	I(5)	60+		60+
10E	X(2)	2		2
10F	X(1)	1/2	less than	1/2
5B	V(2)	(a)		(a)
4D	IV(2)	(a)		(a)
28B	XIX(1)	10		10
29A	XX(1)	40		40
28C	XIX(2)	20		20
21K	XVI(8)	10		10
21L	XVI(9)	20		20
21M	XVI(10)	20		20
		Top Coats		
3B	III(1)	10		10
1D	I(4)	40		40
4B	IV(3)	20		20
8C	IX(2)	20		20
8D	IX(3)	20		10
8E	IX(4)	10		(a)
6D	VI(2)	5	less than	1/2
6F	VI(3)	40		40
8F	IX(5)	40		20

TABLE 2

Test Results of Component Coatings

	(2) pact n 36°F	Ultrasonic Tank Test (2),(3) (Initial Erosion Failure Time, Hours)	Remark
s			
	60+	1	
	60+	1/4	
	60+	1-1/2	
	60+	1/4	
	10	2	
	60+	3	
	40	3	
	60+	9-1/2	
	2	1-1/4	
han	1/2	3-1/2	
	(a)	3/4	
	(a)	4-1/2	
	10	1-1/2	
	40	1	
	20	1-1/2	
	10	1	
	20	3/4	
	20	1/2	
	10	3/4	
	40	1/2(b)	
	20	1	
	20	2	
	10	1-3/4	
	(a)	1-1/2	Applied
han	1/2	1	
	40	2	
	20	7	

Remarks

Applied over VI(1)

TA

Test Results of Co

Coating No.	Component Code No. (1)	Flexibility-Impact % Elongation (2) 70°F	36°F	Ul (Initial
		Top Coats		
9B	I(6)	60+	60+	
7B	VII(1)	(a)	(a)	No erosion i
7F	VII(1)	(a)	(a)	No erosion i
8L	IX(12)	60+	60+	
11C	XI(1)	60+	60+	No erosion i
13A	XIII(1)	60+	60+	No erosion i
13B	XIII(2)	60+	60+	No erosion i
14A	XIV(1)	60+	40	
14B	XIV(1) + IX(7)	10	5	
14C	XIV(1) + IX(3)	5	2	
14D	XIV(1) + IX(12)	60+	20	
15A	XII(9)	60+	40	
15B	XII(9) + XIV(1)	60+	60+	No erosion i
15C	XII(9) + XIV(1)	60+	60+	
15D	XII(9) + IX(2)	1/2	1/2	
16A	I(2) + IX(2)	5	5	
16B	I(3) + IX(2)	5	2	
11D	XI(1)	60+	60+	No erosion i
11E	XI(1)	60+	60+	No erosion i
18A	XII(1)	60+	60+	No erosion i
18B	XII(7)	60+	60+	No erosion i
18C	XII(2)	20	20	
18D	XII(2)	60+	60+	No erosion i
21A	XVI(1)	60+	60+	No erosion i
21B	XVI(2)	60+	60+	No erosion i
21C	XVI(3)	20	10	
21D	XVI(4)	60+	60+	
18E	XII(2)	10	10	No erosion i
23A	IX(5)	10	10	
23B	IX(5) + XVII(1)	40	20	

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TABLE 2

Test Results of Component Coatings

Ultrasonic Tank Test (2), (3) (Initial Erosion Failure Time, Hours)	Remarks
1-1/4	
No erosion in 24	
No erosion in 24	Applied over VIII(1)
2-1/4	
No erosion in 24	Applied over I(1) and I
No erosion in 24	Applied, over I(1) and X
No erosion in 24	
2-3/4	20% solution plus 2% T.
1-1/4	Mixture - 1:1 by volume
2-1/4	Mixture - 1:1 by volume
3-1/3	Mixture - 1:1 by volume
8 to 24(c)	Added drier
No erosion in 24	Mixture - 3:1 by volume
2	Mixture - 1:4 by volume
3/4	Mixture - 1:10 by volume
1	Mixture - 1:1 by volume
5-1/2	Mixture - 1:1 by volume
No erosion in 24	
No erosion in 24	Mixture - 9:1 Xylol by volume
No erosion in 24	
No erosion in 24	
8 to 24(d)	Mixture of Asbestine, Xylol and A
No erosion in 24	
No erosion in 24	
No erosion in 24	
1-3/4	
1/2	
No erosion in 24	Mixture of Asbestine, Xylol and A
4-1/4	
5-1/3	Mixture of 40 cc IX(5) and 3.0 gr

Remarks

Applied over VIII(1)

Applied over I(1) and I(3)
Applied, over I(1) and XIII(4)

20% solution plus 2% T.C.P.
Mixture - 1:1 by volume
Mixture - 1:1 by volume
Mixture - 1:1 by volume
Added drier
Mixture - 3:1 by volume
Mixture - 1:4 by volume
Mixture - 1:10 by volume
Mixture - 1:1 by volume
Mixture - 1:1 by volume

Mixture - 9:1 Xylol by volume

Mixture of Asbestine, Xylol and Amyl Acetate

Mixture of Asbestine, Xylol and Amyl Acetate

Mixture of 40 cc IX(5) and 3.0 grams XVII(1)

TABL

Test Results of Co

Coating No.	Component Code No. (1)	Flexibility-Impact % Elongation (2) 70°F	36°F	Ultr (Initial
		Top Coats		
23C	IX(5) + XVII(2)	20	20	
23D	XII(2) + XVII(1)	40	40	
23E	XII(2) + XVII(2)	20	20	No erosion in
23F	XII(2) + XVII(1)	20	20	
23G	XII(2) + XVII(2)	20	20	
23H	XII(1) + XVII(1)	20	20	
23I	XII(1) + XVII(2)	20	10	
21F	XVI(5)	20	20	
21H	XVI(6)	40	40	
21J	XVI(7)	20	20	
27A	XVIII(1)	1	1/2	
31A	XXI(1)	60+	60+	
21N	XVI(11)	10	10	
21O	XVI(12)	20	20	
21P	XVI(13)	20	20	

NOTES: (1) Supplier source and identification of materials are listed in Table 1.
(2) Flexibility-Impact and ultrasonic tank test performed on a 1.5 mil dry film of component
(3) Time indicated is that required for initial perforation (erosion) of coating to substrat

(a) Not determined.
(b) Substantial flaking and slight erosion of film to I(1).
(c) Erosion of film to metal substrate between 8 and 24 hours during period when no observati
(d) Erosion of film to I(1) between 8 and 24 hours during period when no observations were m

TABLE 2

Test Results of Component Coatings

	Ultrasonic Tank Test (2),(3) (Initial Erosion Failure Time, Hours)	Remarks
	3-1/2	Mixture of 40 cc IX(5) and 3.0 Grams
	16 to 24 (c)	Mixture of 48 Grams XII(2),15 Grams Xylol and 6 Grams Amyl Acetate
No erosion in	24	Mixture of 48 Grams XII(2), 15 Grams Xylol, and 6 Grams Amyl Acetate
	8 to 24 (c)	Mixture of 48 Grams XII(2), 5 Grams Xylol, 6 Grams Amyl Acetate, and 2
	8 to 24 (c)	Mixture of 48 Grams XII(2), 5 Grams Xylol, 6 Grams Amyl Acetate, and 2
	8 to 24 (c)	Mixture of 40 cc XII(1) and 3 Grams
	8 to 24 (c)	Mixture of 40 cc XII(1) and 3 Grams
	8 to 24 (d)	
	1-1/4	
	1-1/4	
	5-1/2	
	2	
	1/2	
	3/4	
	1/2	

film of component coating applied over 0.5 mil dry film I(1) and a 31 gauge metal panel, after air drying 10
oating to substrate or to undercoat.

d when no observations were made.
bservations were made.

Remarks

Mixture of 40 cc IX(5) and 3.0 Grams XVII(2)
Mixture of 48 Grams XII(2),15 Grams XVII(1),6 Grams Xylol and 6 Grams Amyl Acetate
Mixture of 48 Grams XII(2), 15 Grams XVII(2), 6 Grams Xylol, and 6 Grams Amyl Acetate
Mixture of 48 Grams XII(2), 5 Grams XVII(1), 6 Grams Xylol, 6 Grams Amyl Acetate, and 20 Grams Asbestine
Mixture of 48 Grams XII(2), 5 Grams XVII(2), 6 Grams Xylol, 6 Grams Amyl Acetate, and 20 Grams Asbestine
Mixture of 40 cc XII(1) and 3 Grams XVII(1)
Mixture of 40 cc XII(1) and 3 Grams XVII(2)

1 dry film I(1) and a 31 gauge metal panel, after air drying 10 to 14 days.

Coating No.	Coating System (with Coded Nos. of Component Coatings) (1)	Flexibility-Impact (2) % Elongation 70°F	36°F	Ultrasonic Tank T (Initial Erosion Failu
1A	Standard Navy System			
	1 coat I(1) 4 coats I(2) 2 coats I(4)	1/2 (cracks in topcoat I(4) only)	1	0.9 - substantial fl erosion to I(2 1-1/4 - erosion to m
9A	1 coat I(1) 2 coats VIII(1) 20 coats VII(1) 2 coats I(5) 2 coats I(6)	60+	60+	24 - pinpoint erosio I(6) only - und intact.
28A-1	1 coat I(1) 1 coat XIX(1) 1 coat XIX(2) 1 coat XIX(1) 2 coats I(4)	less than 1/2 (cracks to 2nd coat of XIX(1))	less than 1/2	1-1/2 erosion to 2n After 24 hrs. subst 1st coat of XIX(1) entire surface of t
24A-2	Mare Island Exterior Dome Coating			
	1 coat I(1) 4 coats I(2) 1 coat XIII(3) 15 coats XIII(1) 2 coats I(6)	5 (cracks to XIII(1))	2	24 - few pinholes i only. Remaini intact.
8G	1 coat IX(1) 2 coats IX(5)	5 (cracks to IX(1))	5	7-1/2 - erosion to
8H	1 coat IX(1) 1 coat I(3) 2 coats IX(7)	5 (cracks to IX(1))	5	2 - erosion to meta

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TABLE 3

Test Results of Coating Systems for Sonar Domes

Ultrasonic Tank Test[2,3] (Initial Erosion Failure Time, Hours)	Cavitation Erosion after 1 Hour in Fresh Water[4] 100 fps	125 fps	150 fps
0.9 - substantial flaking and slight erosion to I(2). 1-1/4 - erosion to metal base.	High erosion of coating only	High erosion to steel	High erosion to steel
24 - pinpoint erosion of I(5) and I(6) only - undercoat VII(1) intact.	No damage	Slight erosion of I(5), I(6)	Erosion of I(5), I(6)
1-1/2 erosion to 2nd coat of XIX(1). After 24 hrs. substantial erosion to 1st coat of XIX(1) and checking of entire surface of topcoat I(4).	Coating eroded	Coating eroded	Coating eroded to steel
24 - few pinholes in I(6) topcoat only. Remaining coating intact.	Erosion of I(6) only. Coating XIII(1) intact.	Erosion of I(6) only. Coating XIII(1) intact.	Erosion of I(6) only. Coating (1) intact.
	No additional erosion after 6 hrs. of exposure.	No additional erosion after 6 hrs. of exposure.	No additional erosion after 6 hrs. of exposure.
7-1/2 - erosion to metal base.	High erosion to steel.	High erosion to steel.	High erosion to steel.
2 - erosion to metal base.	High erosion to steel.	High erosion to steel.	High erosion to steel.

(5)

USNUSL Sonar Dome Test Results Exposure to Sonic Pulsations at Dodge Pond	Remarks
Two dome sections (5' x 5') failed after 25 and 75 hours, respectively.	Flaking and erosion in ultrasonic tank test indicates poor adhesion of I(4) topcoat.
1st Dome Section - Not damaged after 212 hours (unsatisfactory because of deep cracks and checks developed after 3 weeks of paint application) 2nd Dome Section - One interior area of dome eroded to metal. Five other areas started to erode after 25 hours.	Failures under USNUSL sonar dome tests due to difficulty in the application of paint to inside of dome, at difficult to reach trusses. Further work warranted, including fewer coats of VII(1), and improved application techniques.
Paint damage occurred after 72 hours.	No further work planned.
No deterioration after 426 hours of exposure. Coated dome prepared by Mare Island.	"Cure period" and brushing of I(6) topcoat are very sensitive and critical, in order to produce a crack-free film surface. Present application time period is extensive.
No submission to USNUSL planned.	Preliminary indications are that coating system is better than the standard Navy vinyl system, as regards "erosion". Improvement necessary for ultimate use.
No submission to USNUSL planned.	Preliminary indications are that coating system is slightly better than the standard Navy vinyl system, as regards "erosion". Improvement necessary for ultimate use.

Coating No.	Coating System (with Coded Nos. of Component Coatings) (1)	Flexibility-Impact (2) % Elongation 70°F	36°F	Ultrasonic Tank Tes (Initial Erosion Failure
22F	1 coat I(1) 1 coat I(3) 3 coats XI(1)	60+	60+	24 - no erosion
22B	1 coat I(1) 3 coats I(3) 2 coats XII(1) 2 coats I(6)	10 (cracks to XII(1))	5	24 - pinpoint of I(6) XII(1) coating i
22C	1 coat I(1) 1 coat I(3) 2 coats XI(1) 1 coat XXIII(1) 2 coats I(6)	2 (cracks to XI(1))	2	24 - few pinholes in only. Remaining
22E	1 coat I(1) 1 coat I(3) 2 coats XI(1) 2 coats XII(1)	10	5	24 - no erosion
22G	1 coat I(1) 1 coat XXIII(1) 2 coats XII(1)	20 (cracks to I(1))	20	24 - no erosion
25B	1 coat I(1) 1 coat I(2) 2 coats VIII(1) 4 coats VII(1) 3 coats XI(1) 1 coat XXIII(1) 2 coats I(6)	1 (cracks to XI(1)	1/2	24 - few pinholes in Remaining coatin

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TABLE 3

Test Results of Coating Systems for Sonar Domes

sonic Tank Test (2),(3) (rosion Failure Time, Hours)	Cavitation Erosion after 1 Hour in Fresh Water (4) 100 fps	125 fps	150 fps	U Exposur
	No erosion	No erosion	No erosion	
erosion	No erosion after 6 hours of exposure	No erosion after 6 hours of exposure	No erosion after 6 hours of exposure	Submiss
npoint of I(6) only. I(1) coating intact.	---------(6)	---------(6)	----------(6)	
pinholes in I(6) topcoat ly. Remaining coat intact.	---------(6)	---------(6)	----------(6)	
erosion	---------(6)	---------(6)	----------(6)	
erosion	---------(6)	---------(6)	----------(6)	
pinholes in I(6) only. maining coating intact.	---------(6)	---------(6)	----------(6)	

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(5) USNUSL Sonar Dome Test Results posure to Sonic Pulsations at Dodge Pond	Remarks
bmission to USNUSL planned.	Erosion and elongation characteristics very good. Further work required to improve application techniques and for incorporation of antifouling properties in the coating system.
	Indications are that coating system is superior to standard Navy vinyl system. Further work planned including use of XXIII(1) under I(6) topcoat.
	Indications are that coating system is superior to standard Navy vinyl system. Further work necessary to improve application techniques, and determine if fewer coats of XI(1) are sufficient.
	Erosion characteristics very good. Further work required for incorporation of antifouling properties in the coating system.
	Erosion characteristics very good. Further work necessary, including use of 3-4 coats of XII(1). Also, incorporation of antifouling properties in the coating system.
	Erosion characteristics good. Further work necessary, including fewer coats and improvement of application technique.

Coating No.	Coating System (with Coded Nos. of Component Coatings) (1)	Flexibility-Impact (2) % Elongation 70°F	36°F	Ultrasonic Tank Tes (Initial Erosion Failure
25C	1 coat I(1) 1 coat I(2) 2 coats VIII(1) 4 coats VII(1) 2 coats XI(1) 1 coat XXIII(1) 2 coats I(6)	1/2 (cracks to XI(1))	1/2	24 - chain of pinholes topcoat only. Re coating intact.

NOTES: (1) Supplier source and identification of materials are listed in Table 1.
(2) Tests for flexibility-impact and ultrasonic tank test made on coating system applied on 31
(3) Time indicated is that required for initial perforation (erosion) of coating to substrate
(4) Erosion resistance of coating evaluated on the basis of condition of film after exposure (
(5) Results shown are reported in USL Technical Memorandum No. 933-174-64 of 23 June 1964.
(6) No tests conducted. Sufficient merit shown to warrant further modification.

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TABLE 3

Test Results of Coating Systems for Sonar Domes

rasonic Tank Test (Erosion Failure Time, Hours) (2),(3)	Cavitation Erosion after 1 Hour in Fresh Water (4) 100 fps	125 fps	150 fps	U Exposur
ain of pinholes in I(6) pcoat only. Remaining ating intact.	---------(6)	--------(6)	--------(6)	

em applied on 31 gauge metal panel, after air-drying 10 to 14 days. Cavitation erosion also performed after 10
ng to substrate or to undercoat.
after exposure (varies with time required to perforate film).
23 June 1964.
n.

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(5)

USNUSL Sonar Dome Test Results
Exposure to Sonic Pulsations at Dodge Pond

Remarks

Erosion characteristics good. Further work necessary, including fewer coats and improvement of application technique.

after 10 to 14 days of air-drying of film.

Test Re

Coating No.	Coating System Component Code No.(1)	Flexibili % Elo 70°F
2A	I(1), I(3), I(4)	1/2
3A	I(1), I(3), III(1)	5
10B	I(1), X(1), X(2), X(3)	1/2
10A	I(1), X(1), X(2)	1/2
6E	I(1), VI(3)	60+
5A	V(1), V(2), V(3)	1/2
10C	X(1), X(2)	1/2
10D	X(1), X(2), X(3)	1/2
4A	IV(1), IV(2), IV(3)	5
8H-1	IX(1), I(3), IX(7)	5
8I	IX(1), I(3), IX(3)	5
8I-1	IX(1), I(3), IX(3)	5
8J	IX(1), I(3), IX(4)	1
8J-1	IX(1), I(3), IX(4)	1
11A	IX(1), I(3), XI	60+
9D	I(1), I(5), I(6)	60+
9E	I(1), I(5), I(6)	60+
9F	I(1), I(5), I(6), IX(6)	(a)
7A	I(1), VIII(1), VII(1)	60+
7A-1	I(1), VIII(1), VII(1)	(a)
17A	I(1), VI(3), IX(7)	5
17B	I(1), VI(3), IX(5)	10
17C	I(1), I(3), VI(3), IX(4), IX(12)	40
20A	I(1), XV(1)	5
20B	I(1), XV(2)	20
20C	I(1), XV(1), XV(2)	10
11F	I(1), I(3), XI(1)	60+
11G	I(1), I(3), XI(1)	60+
22A	I(1), I(3), XII(1)	20
22D	I(1), I(3), XI(1), I(6)	1/2
22H	I(1), XXIII(1), XII(1)	40
19A	I(1), I(3), XI(1)	20
19B	I(1), I(3), XI(1)	60+
19C	I(1), I(3), XI(1)	40
19D	I(1), I(3), XI(1), XXIII(1), I(6)	2
25A	I(1), I(2), VIII(1), VII(1), XXIII(1), I(6)	1

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TABLE 4

Test Results of Coating Systems for Sonar Domes

Flexibility-Impact (2) % Elongation 70°F	36°F	Ultrasonic Tank Test (2), (3) (Initial Erosion Failure Time, Hours)		
1/2	1		1/2	
5	1		1	
1/2	1/2		3/4	
1/2	1/2		1 hr., 5 min.	
60+	60+		3-1/3	
1/2	1/2		1/3	
1/2	1/2		1-1/4	
1/2	1/2		3/4	
5	5		2-1/4	
5	5		1-3/4	
5	5		1-1/4	
5	10		1-1/3	
1	1		1	
1	1		1-1/4	
60+	60+		8+	
60+	60+		55 min.	
60+	60+		2	
(a)	(a)		1-3/4	
60+	60+	No erosion in	24	Anti
(a)	(a)	No erosion in	24	Anti
5	2		2	
10	2		4-3/4	
40	10		2	
5	1		1	
20	10		1-1/4	
10	1		1-1/2	
60+	60+	No erosion in	24	Anti
60+	60+	No erosion in	24	Anti
20	10		8 to 24(b)	Blis
1/2	1/2		3	
40	20		8 to 24(c)	
20	20	No erosion in	24	Smal
60+	60+		(a)	Dry
40	40		(a)	Pinh
2	2		24(d)	
1	1/2		24(e)	

(2), (3) c Tank Test n Failure Time, Hours)	Remarks
1/2	
1	
3/4	
1 hr., 5 min.	
3-1/3	
1/3	
1-1/4	
3/4	
2-1/4	
1-3/4	
1-1/4	
1-1/3	
1	
1-1/4	
8+	
55 min.	
2	
1-3/4	
24	Antifouling topcoat necessary
24	Antifouling topcoat necessary
2	
4-3/4	
2	
1	
1-1/4	
1-1/2	
24	Antifouling topcoat necessary
24	Antifouling topcoat necessary
8 to 24(b)	Blisters on film surface
3	
8 to 24(c)	
24	Small bubbles within film
(a)	Dry time excessive (48 hrs.)
(a)	Pinholes in film surface
24(d)	
24(e)	

Test

Coating No.	Coating System Component Code No.(1)	Flexibility- % Elongat
		70°F
1A-1	I(1), I(2), I(4)	1/2
25A-1	I(1), I(2), VIII(1), VII(1), XXIII(1), I(6), I(7)	1
24A	I(1), I(2), XIII(3), XIII(1), I(6)	2
24B	I(1), I(2), XIII(3), XIII(2), I(7)	20
24A-1	I(1), I(2), XIII(3), XIII(1), I(6)	2
21E	I(1), XVI(5)	1/2
21G	I(1), XVI(6)	1/2
21I	I(1), XVI(7)	1/2
28A	XIX(1), XIX(2)	1/2
28D	I(1), XIX(1), XIX(2), IX(2)	1
8J-2	I(1), I(3), IX(2), IX(4)	20
24A-3	I(1), I(2), XIII(3), XIII(1), I(6)	2
24A-4	I(1), I(2), XIII(3), XIII(1), I(6)	2
32A	I(1), XXII(1), XXII(2), I(4)	(a)
32B	XXII(7), XXII(2), I(4)	(a)
32C	I(1), XXII(1), XXII(2), XXII(3)	(a)
32D	XXII(4), XXII(5), XXII(3)	(a)
20A-1	I(1), XV(1)	5
20B-1	I(1), XV(2)	20

NOTES: (1) Supplier source and identification of material are listed in Table 1.
(2) Tests for flexibility-impact and ultrasonic tank test made on coating system appl
(3) Time indicated is that required for initial perforation (erosion) of coating to

(a) Not determined.
(b) Erosion to primer I(3).
(c) Erosion to wash primer I(1).
(d) Few pinholes in topcoat I(6) only. Remaining coating intact.
(e) Cluster of pinholes to XXIII(1) only. Remaining coating intact.
(f) Some pinholes to XIII(1)
(g) Some pinholes to XIII(2)

TABLE 4

Test Results of Coating Systems for Sonar Domes

Flexibility-Impact (2) % Elongation 70°F	Flexibility-Impact (2) % Elongation 36°F	Ultrasonic Tank Test (2), (3) (Initial Erosion Failure Time, Hours)
1/2	1/2	1
1	1	24(e)
2	2	24(f)
20	10	24(g)
2	2	24(f)
1/2	1/2	no erosion in 24
1/2	1	1/2
1/2	1/2	3-3/4
1/2	1/2	1-1/4
1	1/2	2-1/2
20	10	2-1/2
2	2	(a)
2	1	24(d)
(a)	(a)	2
(a)	(a)	2
(a)	(a)	1-1/2
(a)	(a)	1
5	1	1-1/4
20	10	1-1/3

Table 1.
n coating system applied on 31 gauge metal panel after 10 to 14 days of air-drying of film.
sion) of coating to substrate or to undercoat.

et.

(2), (3)
Test
lure Time, Hours)

Remarks

)
)
)
)

Film surface is not smooth

4
4
2
2

Cracking of topcoat (I(6)) to XIII(1)

)

Coated panel submitted by manufacturer
Coated panel submitted by manufacturer
/2
Coated panel submitted by manufacturer
Coated panel submitted by manufacturer

4
3

r-drying of film.